Standard QA2 procedure @(EU)ARC:

Current status & future development

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Solar ALMA data reduction issues

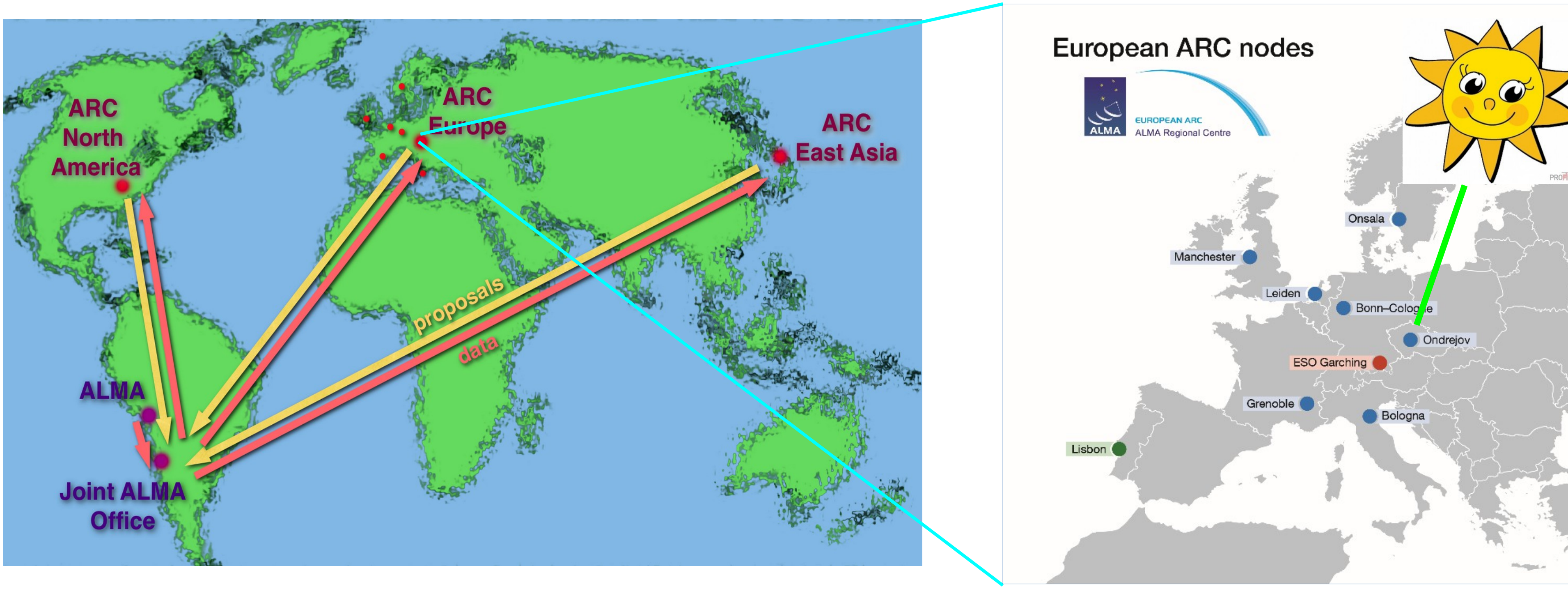
- **Standard QA2-passed ALMA products not sufficient as science-ready data**
  - INT and TP data provided separately, no combination/feathering
  - Time-integrated representative image – smeared-out by internal solar dynamics
  - No self-calibration

  → Community effort has started in the direction of calibrated data post-processing – this is why we are here (in Europe: UiO Oslo, Uni Ioannina, Uni Zagreb).

- **Standard QA2 procedure for solar data is fully manual so far**
  - Significant man-power at ARCs (Ondrejov node @EUARC) required.
  - Human-introduced errors while editing the scripts by hand.
  - Lack of robustness and homogeneity.
  - Solar ObsMode referred (up to Cy7) as “non standard” (bad impression).

    → **Convergence towards standard ALMA pipeline highly desirable – development in this direction carried out at EU ARC/ESO.**

ALMA Regional Centers / ARCs and the ARC nodes



ALMA Regional Centers – ARCs:
Supporting infrastructure – interface between ALMA observatory and user community

Structure of the European ARC:

- Head in ESO Garching
- Seven nodes across Europe
  - **One in Ondřejov/Prague, Czechia (since 2009)**

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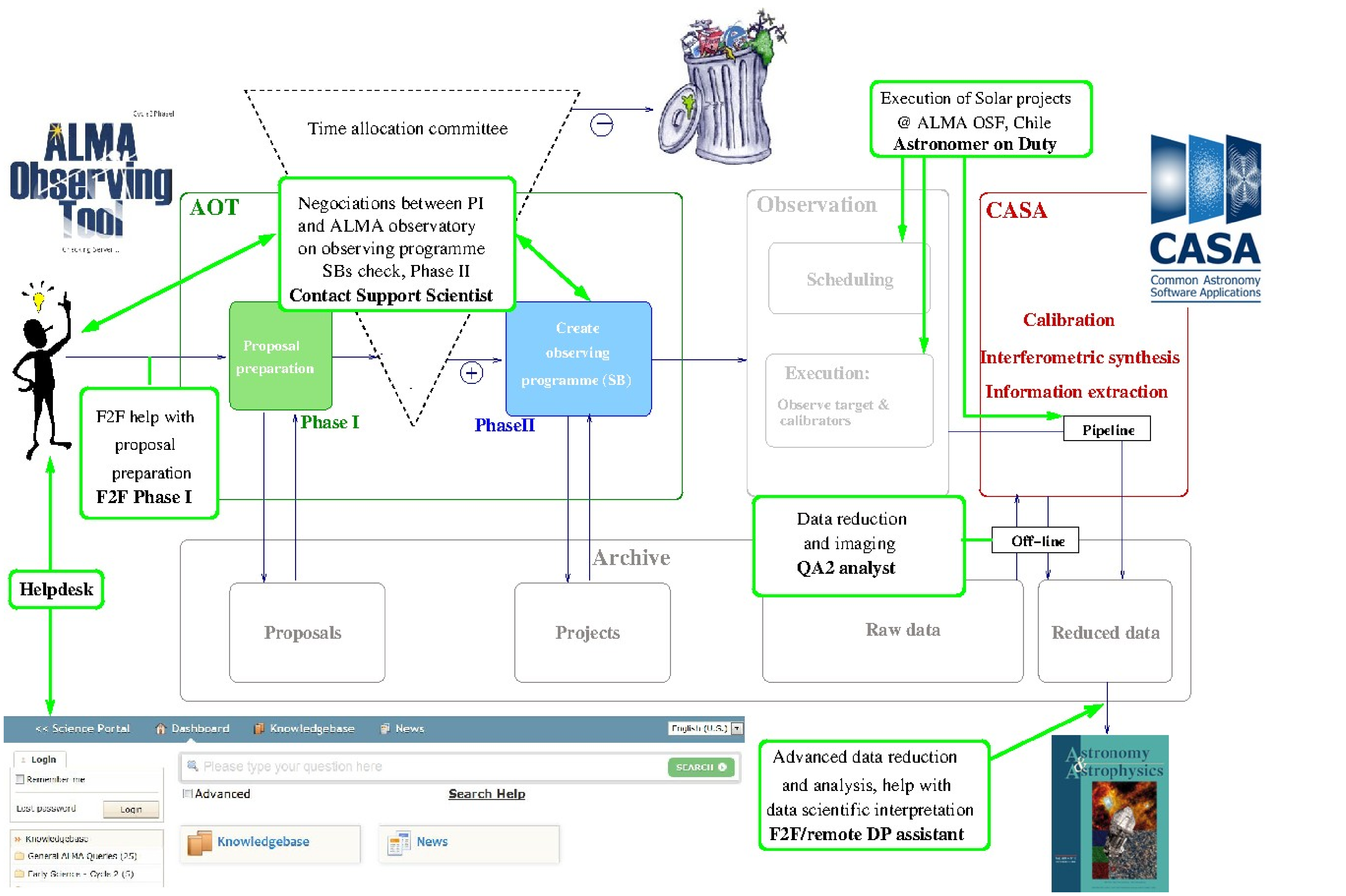
ALMA data flow & ARC services



Standard solar QA2: Unpopular but necessary “black job”

- **Standard QA2 includes**
  - Flagging & calibration of solar data: Results of the manpower and many (sometimes painful) decisions are hidden in the script for calibration).
  - Imaging (time integrated :-( ) & check of the image quality.
  - Running **QA2** post-processing **product-evaluation** scripts.

- **Results of the QA2 procedure**
  - Products (FITS files)
    - The image is integrated over EB duration (~1h) and takes advantage of multi-frequency synthesis (MFS). Good **starting model** for selfCal.
  - Scripts for calibration and imaging (can be invoked from the *scriptForPI*).
    - Script for calibration: One can restore the calibrated measurement set – this is always **the first step for advanced imaging** (time-domain, selfCal).

Standard solar QA2: Unpopular but necessary “black job”

- **The QA2 should be**
  - Error-free – not only serious mistakes but also violation of the *best practice* procedures should be avoided.
  - Robust – work ideally for all datasets (no need to data-tailored procedure).
  - Homogeneous – all PIs should get the qualitatively the same results.
  - Automated as much as possible

    → **Approaching the non-solar data treatment**

Solar QA2: Homogeneity across the all ARCs

Jump

Search

Atacama Large Millimeter/submillimeter Array

In search of our Cosmic Origins

DataProcessing

Hello

Miroslav Barta

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Create personal sidebar

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- Create New Topic
- Index
- Search
- Changes
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- RSS Feed
- Statistics
- Preferences

Webs

- AAER
- ADC

TWiki > DataProcessing Web > QAProceduresForSolarINTData (02 Sep 2018, MiroslavBarta)

Raw edit | Edit | Attach

The QA2 & Packaging of Solar Inteferometric data Cycle 5

Cautions

Known issues

- SCOPS-5181 - E2E5 solar testing.
- PRTSPR-32758 - Incorrect field of view of the synthesized images from the solar MOSAIC data
- The bug in the "sun_reduction_util.py"

Local Solar Experts:

- JAO: Antonio Hales
- EU: Miroslav Barta
- EA: Masumi Shimojo
- NA: Tim Bastian

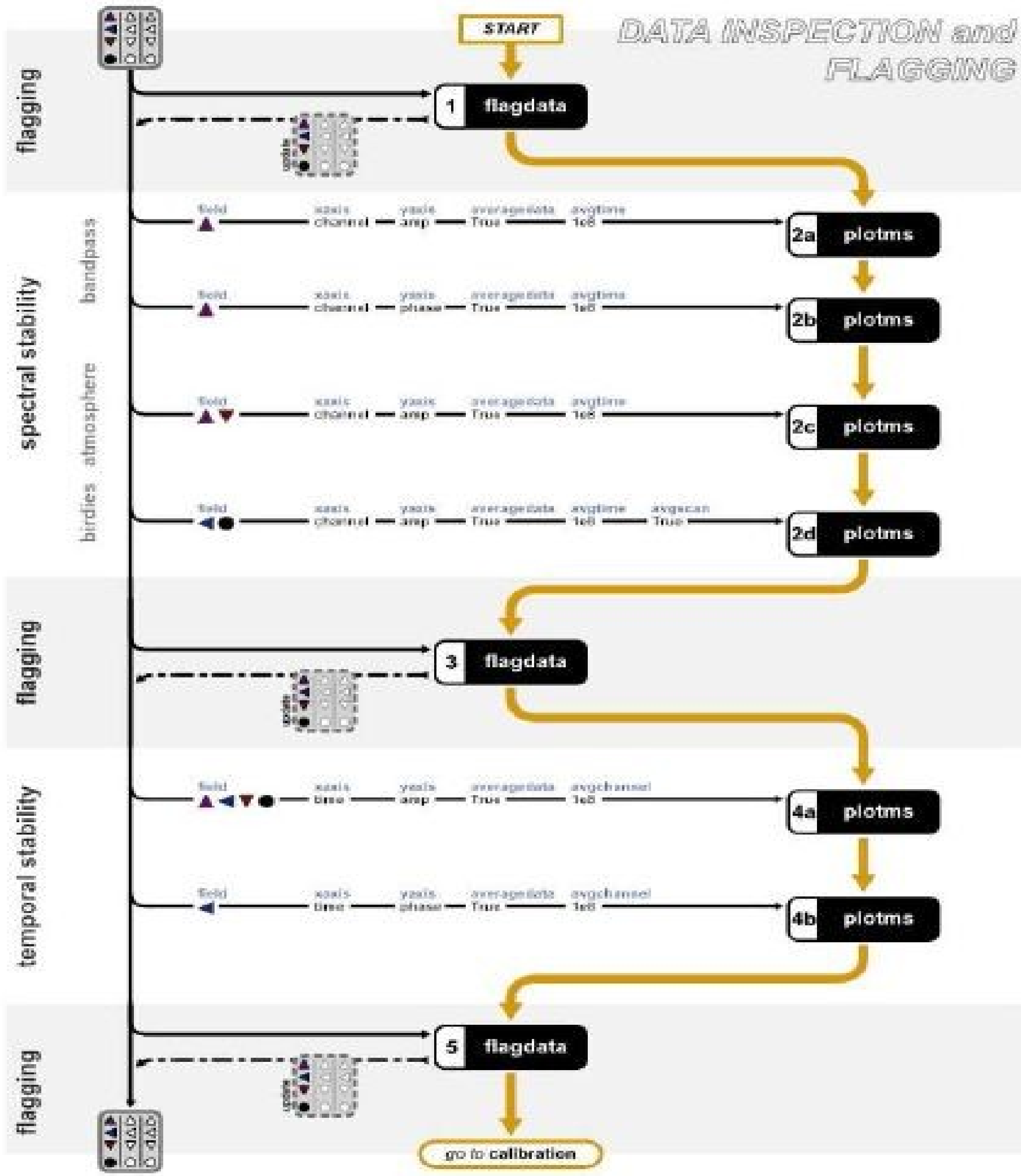
Since 2018: CZ node maintains Central documentation to the Science Solar ALMA data reduction at wikis.alma.cl

ALMA contacts: Catarina Ubach, Dirk Petry

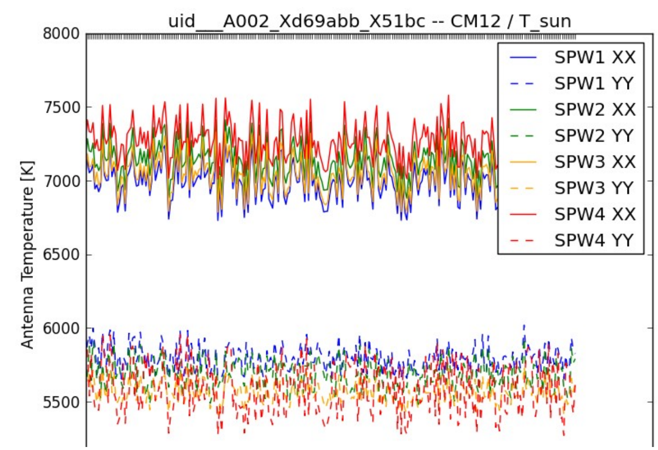
Solar ObsMode specifics & limitations

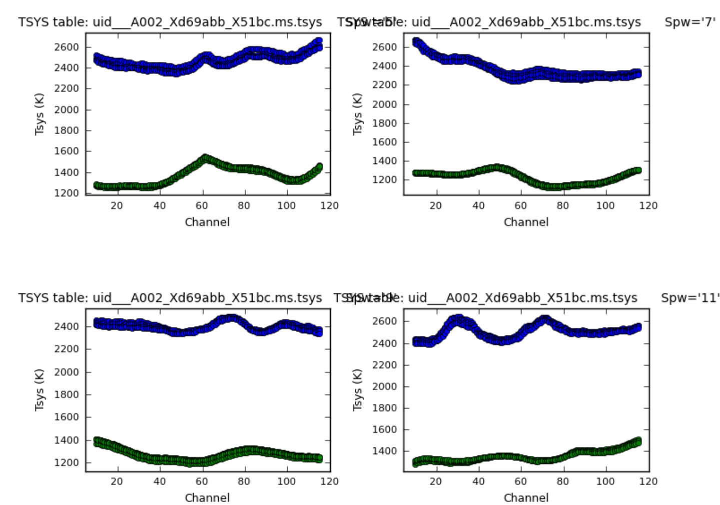
- **"Non-standard" mode**
  - Limited capabilities: Bands 3 & 6 only, TDM only, **configurations limited to ≤ C43-3**,manual cal & imaging,...
  - Combined 12m+7m array, always have complementary TP maps (entire Sun – fast-scanning mode; no regional TP map so far).
  - Using SIS mixer detuning (MD) approach for attenuation of too strong signal from the Sun.
  - Ephemeris targets (solar motion among stars + solar rotation).
  - Literally **manual calibration & imaging** (even no *Script Generator* so far).
- Solar science goals are mostly *Targets of Opportunity* by matter (not technically).
- The Sun is dynamic/highly variable – this breaks down the 'standard' interferometry paradigm on signal accumulation.

Calibration & imaging: Flagging

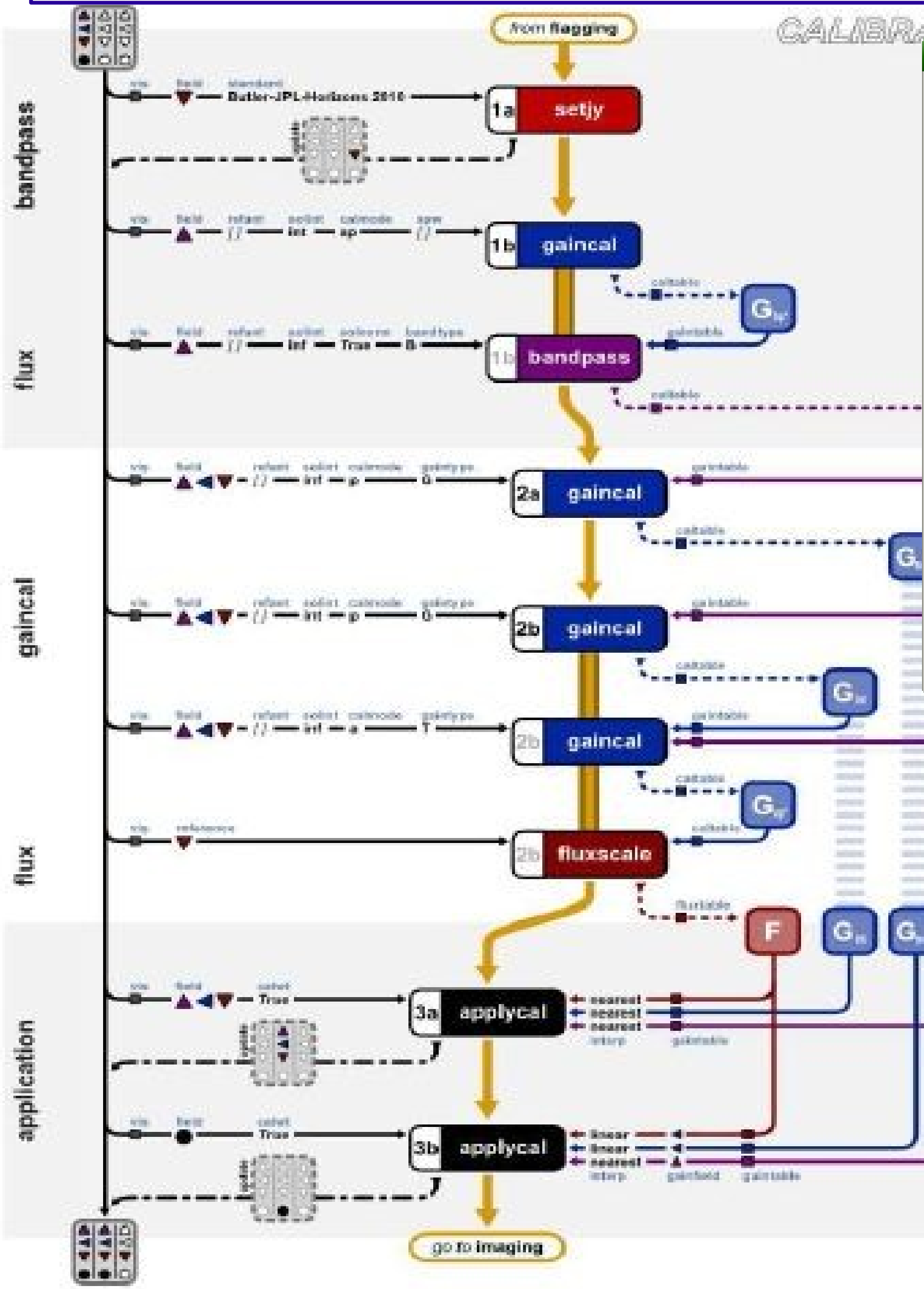


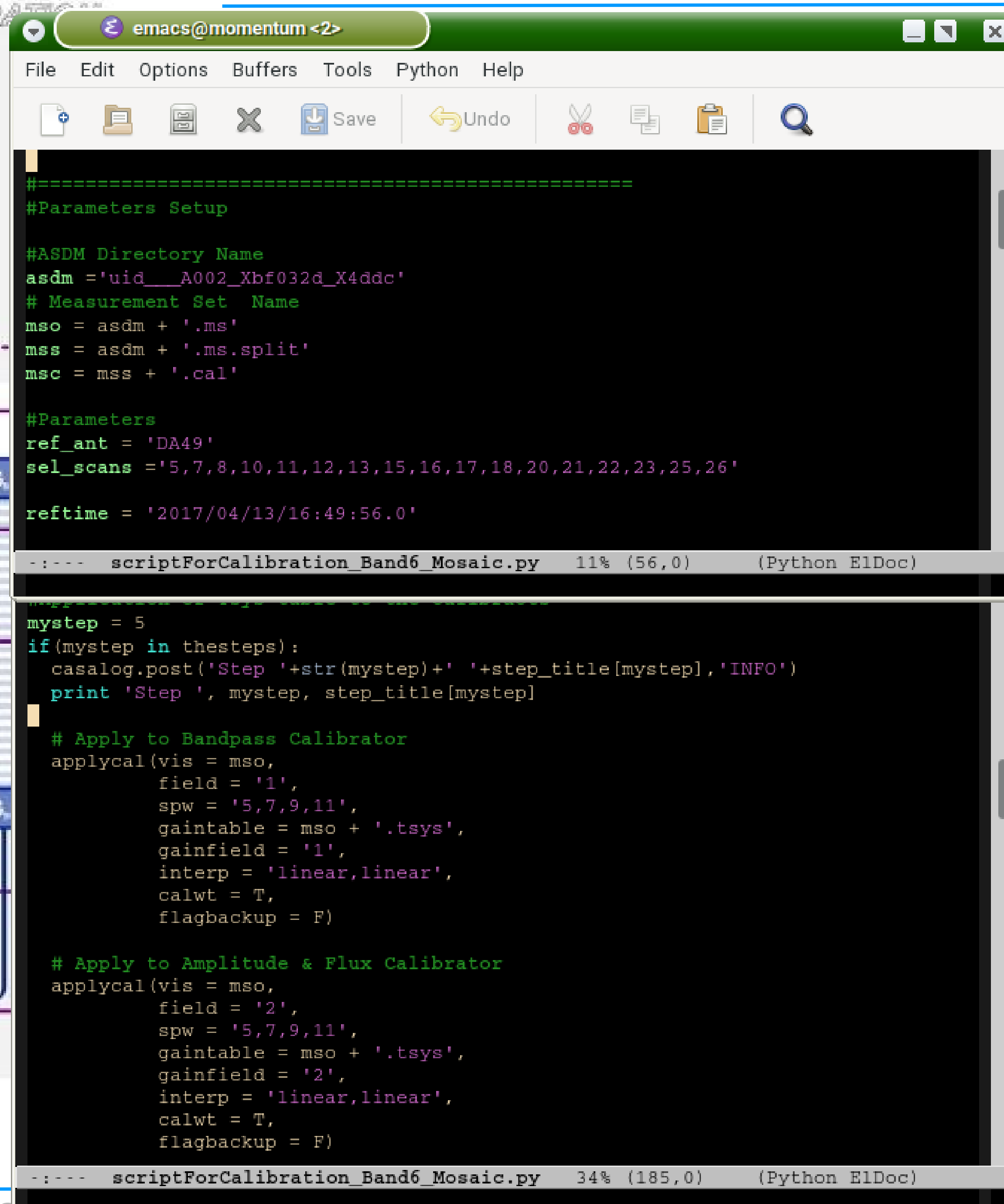
- Solar mode: process demanding on manpower, experience required
- ‘Standard modes’: Heuristics implemented in ALMA pipeline (~75% success rate)
- Our QA2 mission: **Preserve as much as possible data**, remove only the bad ones → many branching points (try and see).
- Opportunity for AI (in far future).





Calibration & imaging: Editing parameters in scripts





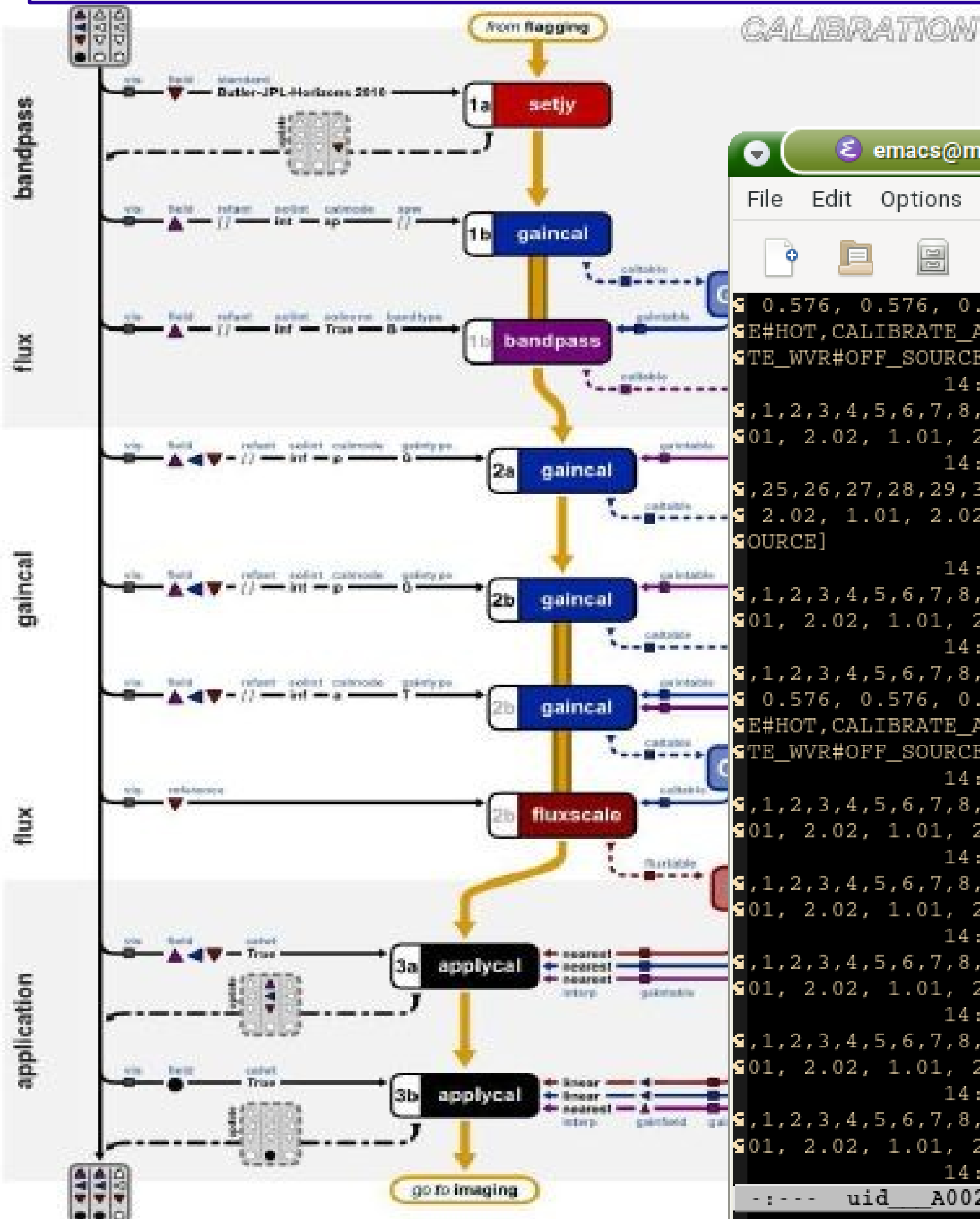

```
#================================================
#Parameters Setup

#ASDM Directory Name
asdm ='uid___A002_Xbf032d_X4ddc'
# Measurement Set  Name
mso = asdm + '.ms'
mss = asdm + '.ms.split'
msc = mss + '.cal'

#Parameters
ref_ant = 'DA49'
sel_scans ='5,7,8,10,11,12,13,15,16,17,18,20,21,22,23,25,26'

reftime = '2017/04/13/16:49:56.0'
```

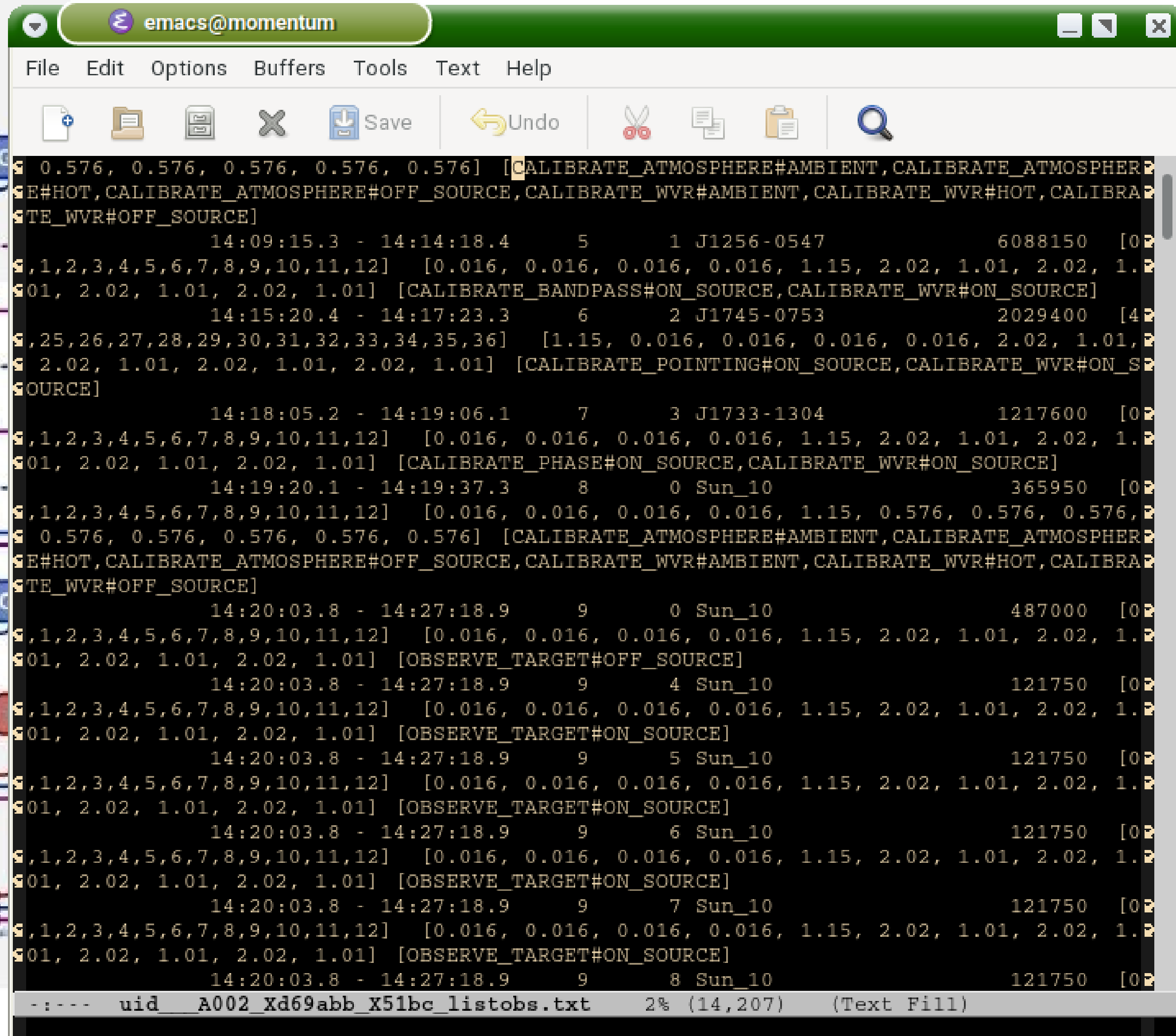
-:--- scriptForCalibration_Band6_Mosaic.py   11% (56,0)   (Python ElDoc)

```
mystep = 5
if(mystep in thesteps):
  casalog.post('Step '+str(mystep)+' '+step_title[mystep],'INFO')
  print 'Step ', mystep, step_title[mystep]

  # Apply to Bandpass Calibrator
  applycal(vis = mso,
           field = '1',
           spw = '5,7,9,11',
           gaintable = mso + '.tsys',
           gainfield = '1',
           interp = 'linear,linear',
           calwt = T,
           flagbackup = F)

  # Apply to Amplitude & Flux Calibrator
  applycal(vis = mso,
           field = '2',
           spw = '5,7,9,11',
           gaintable = mso + '.tsys',
           gainfield = '2',
           interp = 'linear,linear',
           calwt = T,
           flagbackup = F)
```

-:--- scriptForCalibration_Band6_Mosaic.py   34% (185,0)   (Python ElDoc)

Calibration & imaging: Editing parameters in scripts





Calibration & imaging: Recent development @EU ARC

Manual calibration and imaging cook book (up to Cy 5):

1) Take the sample script working well for some EB as a template
2) Do manual diagnostics (listobs(), browsetable(),…) of the MS and set/edit manually the parameters in the cal and img scripts.
   - Many of them: Band 3/6, refAnt, refTime, cal and tgt fields & scans in gaincal()/applycal(), atm lines flagging (different for different bands), mosaic/single-field, img size and cell, gridder mode,…
   - Great potential for mistake/omission
   - Demanding on manpower
   - Dependent on QA2 analyst (calibrated data are not homogeneous across the ARCs).
3) Do manual analysis/selection and flagging
4) Run the cal script step-wise (in 5 batches), modify the params before next step.
5) Perform QA2 analysis/report
6) Run imaging script (after some parameter modifications based on QA2 report).
7) Report on AQUA, prepare package for final check (at ESO) and delivery.

Calibration & imaging: Recent development

“Universal scripts” since Cy 5

- Auto-detection blocks inside the scripts – automated set of all parameters (antPos correction table has to be copy/paste inserted).
- ✔ No need for manual input from the QA2 analyst → reduced manpower, omissions; homogeneity of calibration
- ✗ Big parts of identical code to be copied into all scripts – loss of clarity.
- ➔ What to do: Remove the auto-detect parts into separate code, let this program to write the cal & img scripts for us.

emacs@momentum

File Edit Options Buffers Tools Python Help

```
msc = asdms[0] + '.ms.split.cal'

# +++ Observing band: 3 or 6?
#     Find the 'central' (=average) frequency of all science SPWs, compare it
#     with 100GHz (=nominal Band 3 LO forq.)

tb.open(msc+'/SPECTRAL_WINDOW', nomodify=True)
# Ref. frequencies for all SPWs
obsFreqs = tb.getcol("REF_FREQUENCY")
tb.close()

# Average of ref. frequencies = approx. LO freq.
# NB: science SPWs after split are 0,1,2,3
freqLO=0.25*(obsFreqs[0]+obsFreqs[1]+obsFreqs[2]+obsFreqs[3])
# Calculate relative diff. to nominal LO frequency of Band 3 (1.0x10^11 Hz)
relDiff_B3=abs(freqLO-1.0e11)/1.0e11
# Are we +/- 10% off the 100GHz?
if(relDiff_B3 < 0.1):
    oband=3
    print "Your observation is in Band 3."
else:
    oband=6
    print "Your observation is in Band 6."

# +++ Mosaic or SF? At which field > 0 does the sciTarget mosaic start?

msmd.open(msc)
tgtFields=msmd.fieldsforintent("*OBSERVE_TARGET#ON_SOURCE*")
SunFields=tgtFields.tolist() # numpy::array -> ::list conversion
msmd.done()

'''
# The old style for the same - this, however, includes also OFF_SOURCE fields.
tb.open(msc+'/FIELD', nomodify=True)
fieldNames = tb.getcol("NAME")
SunFields = [i for i, name in enumerate(fieldNames) if name.find("Sun")!=-1]
tb.close()
'''

# How many Sun* fields do we have?
nSunFields=len(SunFields)

if (nSunFields > 1):
    # More than single one - we have mosaic
    isMosaic=True
    mosFirstField=SunFields[0]
-:---  scriptForImaging.py   14% (91,0)     (Python ElDoc)
```

Calibration & imaging: Recent development

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Manual calibration and imaging cook book since Cy 5:

1) Copy the “universal scripts” from the AIV mirror to your QA2 workdir.
2) Do manual analysis/selection and flagging
3) Run 1st half of the cal script, copy/paste its outcome in console to the 2nd half and run the 2nd half
4) Perform QA2 analysis/report
5) Run imaging script.
6) Report on AQUA, prepare package for final check (at ESO) and delivery.

What about standard-modes data reduction?

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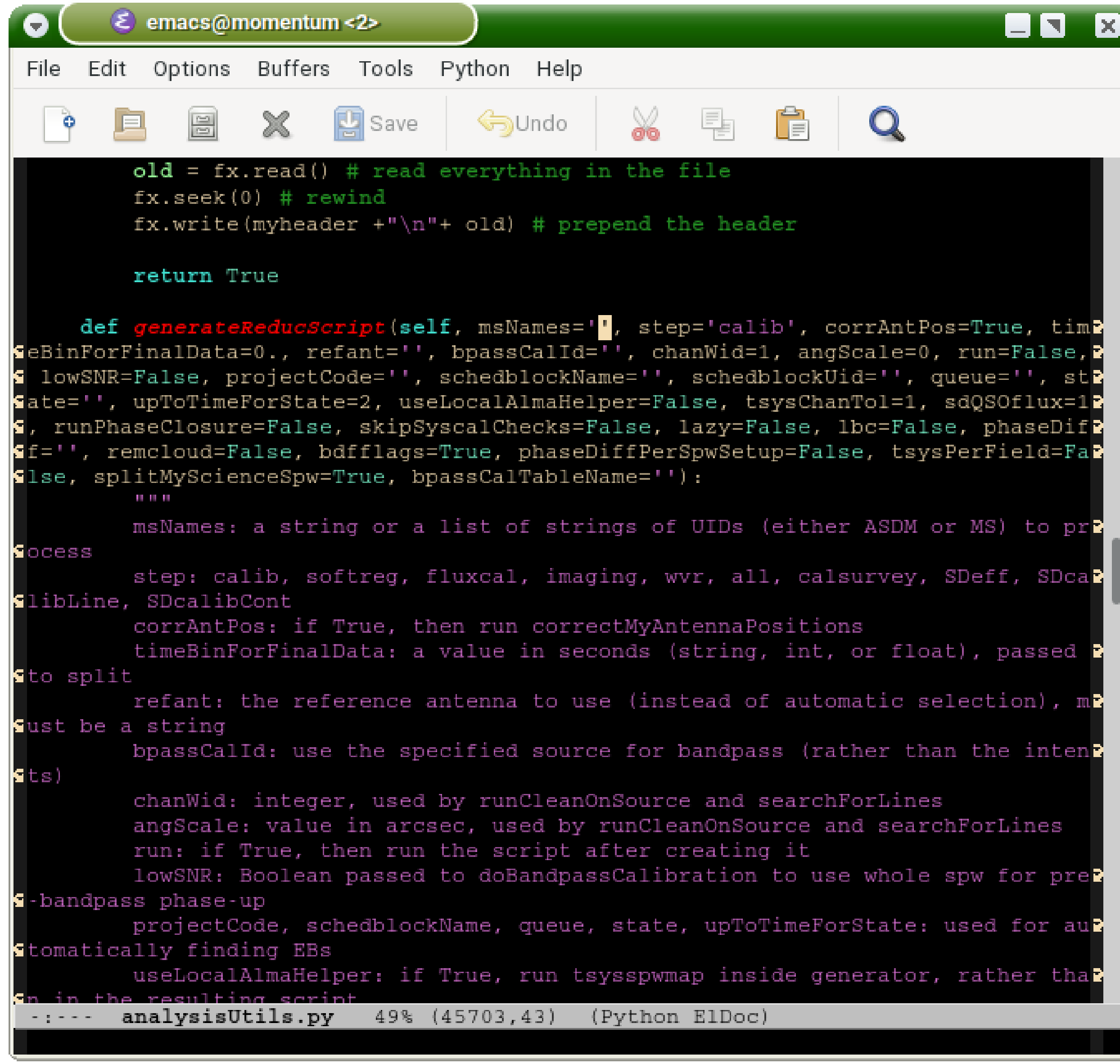
- Cycles 0-2: Fully manual cal & img, editing the scripts (in solar mode: till Cy5)
- Cycle 3, partly 4: **Script Generator**
- Since Cy 4: (almost all dataset) ALMA CASA pipeline calibration and imaging (pipelined imaging being started a bit later).

Script Generator (non-solar)

- Main developer and maintainer Eric Villard, since 2020 Dirk Petry @ESO
- “Father of all scripts”
- Diagnoses the MS and writes the tailored cal & img scripts (img script generator contributed by A. Borkar from our ARC node)
- Part of the *analysisUtils.py* package.



Solar Script Generator: progress report

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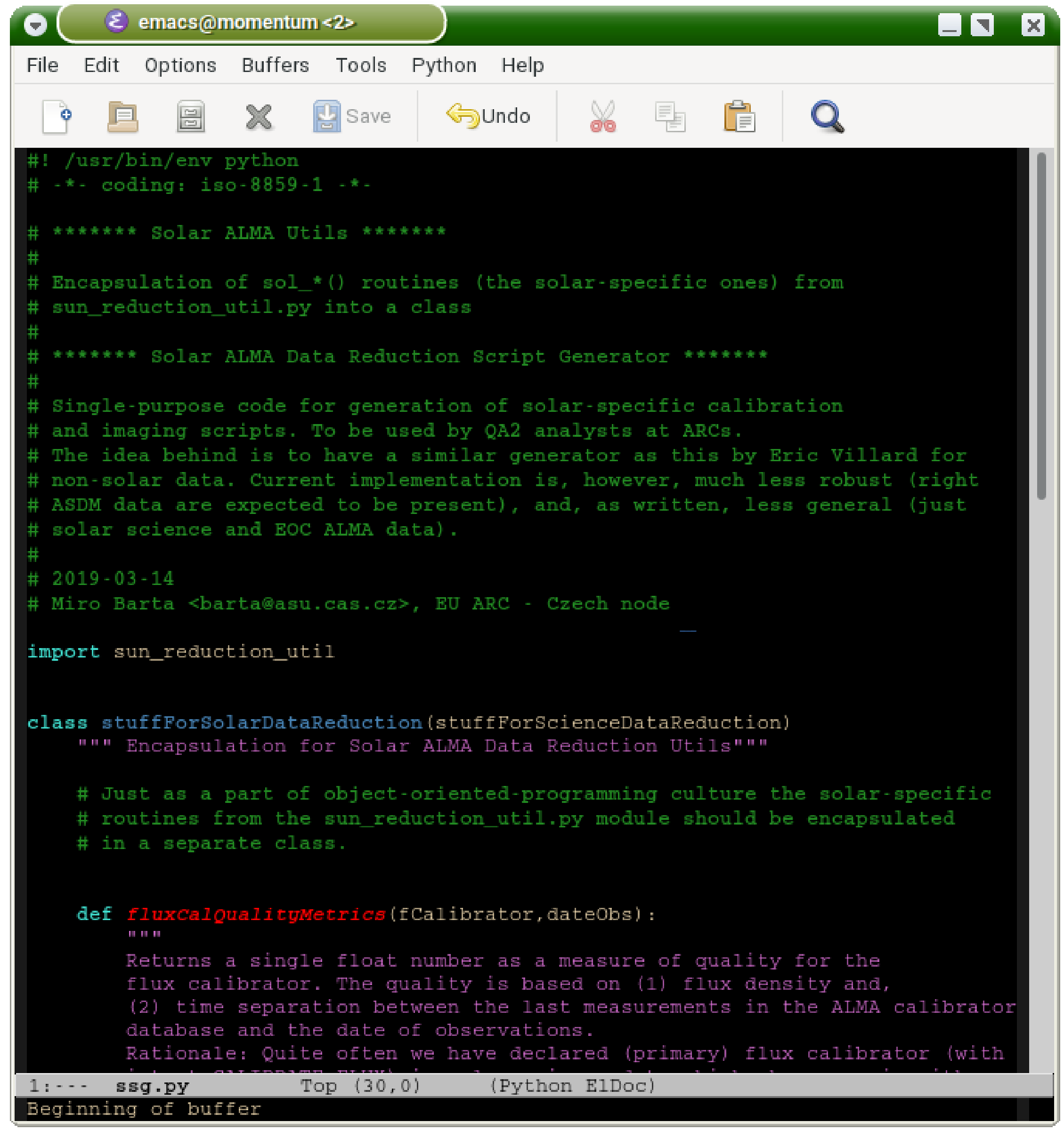
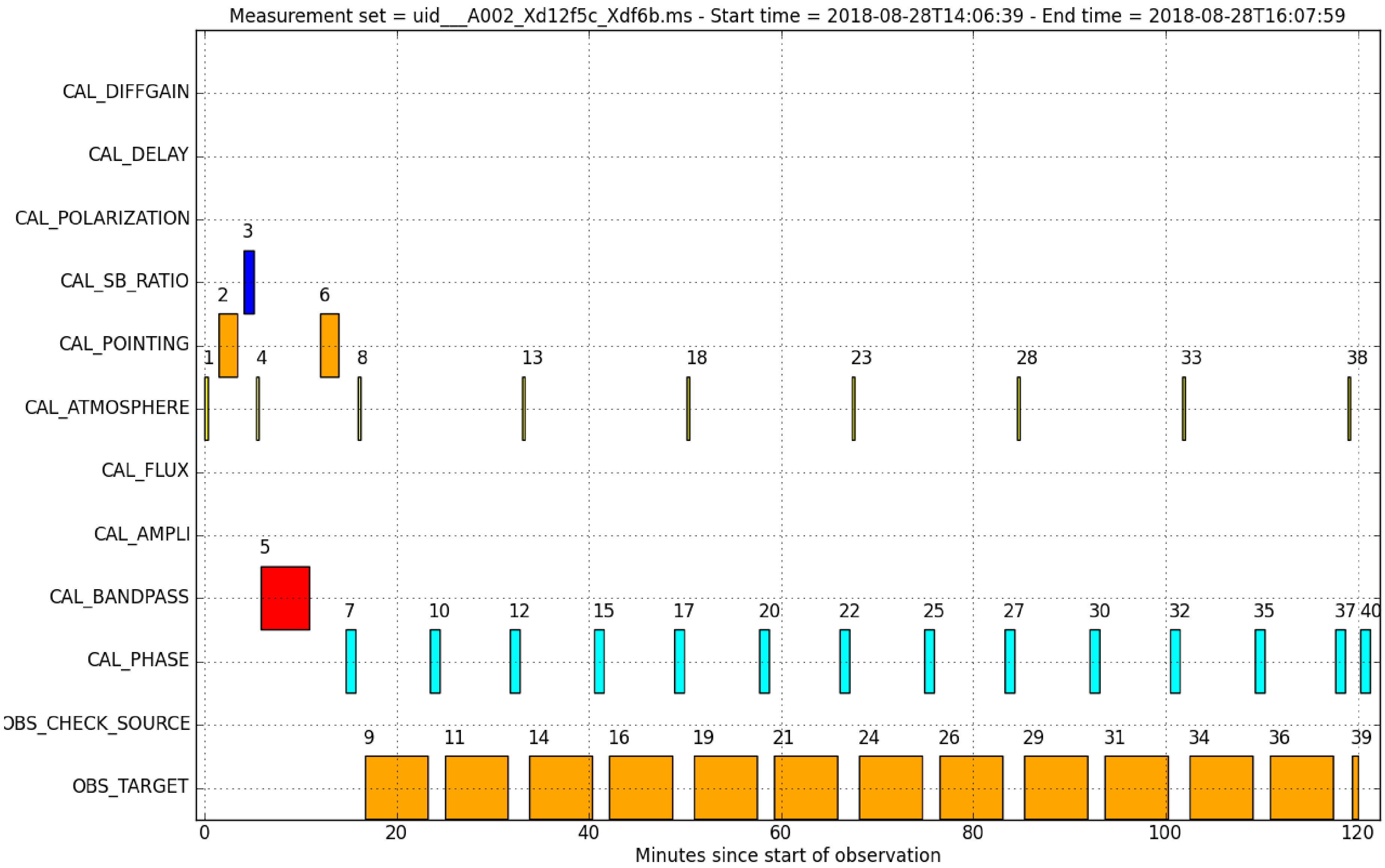
- Based on Python class derived/sub-classed from the E.V.s' *stuffForScienceDataRedution*
- Implements solar-specific calibration steps.
- The same usage as standard SG



Some solar specifics

- T_ant+T_sys calibration – sol_ampcal2() CPU-time demanding (~2days), **we work on MPI paralelization**.
- Flux calibrator: The nominal FluxCal is frequently of low quality (old measurement or weak) – better to use B-cal for amplitude calibration. Implement **quality metrics to choose automatically**.

Calibration & science scans



Final remarks

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- Being a small community and using non-standard mode we are behind the ‘mainstream’ development of ALMA tools (the same situation is, e.g., with the VLBI mode).
- Developed *Solar Script Generator* represents an intermediate step towards future full integration of the solar science data reduction into ALMA pipeline.
- Our mission as the **QA2 analysts / ARC service**: **Do the “black job”** – provide as much as possible high quality **primary calibrated data** for possible further processing (discard problematic data but flag only what is necessary, try to preserve as much as possible). Calibration procedure should be **robust and homogeneous**, working the same way for **all the solar datasets**. We are attempting to make it as fast as possible (reduce manpower). **We have to guarantee that the primary data are of enough high quality**, fulfilling the science requirements stated in AOT. Outcome: (generally applicable) **Solar Script Generator**, to become **part of standard ALMA pipeline** later.
- (Advanced) User point of view: To have their **individual** dataset **imaged the best way**, mine the maximum from the primary calibrated data. Outcome: (individual) advanced imaging scripts include time-domain imaging, self-calibration and TP/INT data combinaton – **this workshop aims mostly at this goal**.

Towards hi-resolution solar ALMA images:

Overcoming current *Solar ObsMode* limitations (*Development Study 2019* proposal)

Miro Barta, Ivica Skokic & Roman Brajsa, EU ARC – Czech node

in collaboration with

Tim Bastian & Dale Gary, NRAO / NA ARC, Masumi Shimojo, NAOJ / EA ARC & the Solar ObsMode Development Team

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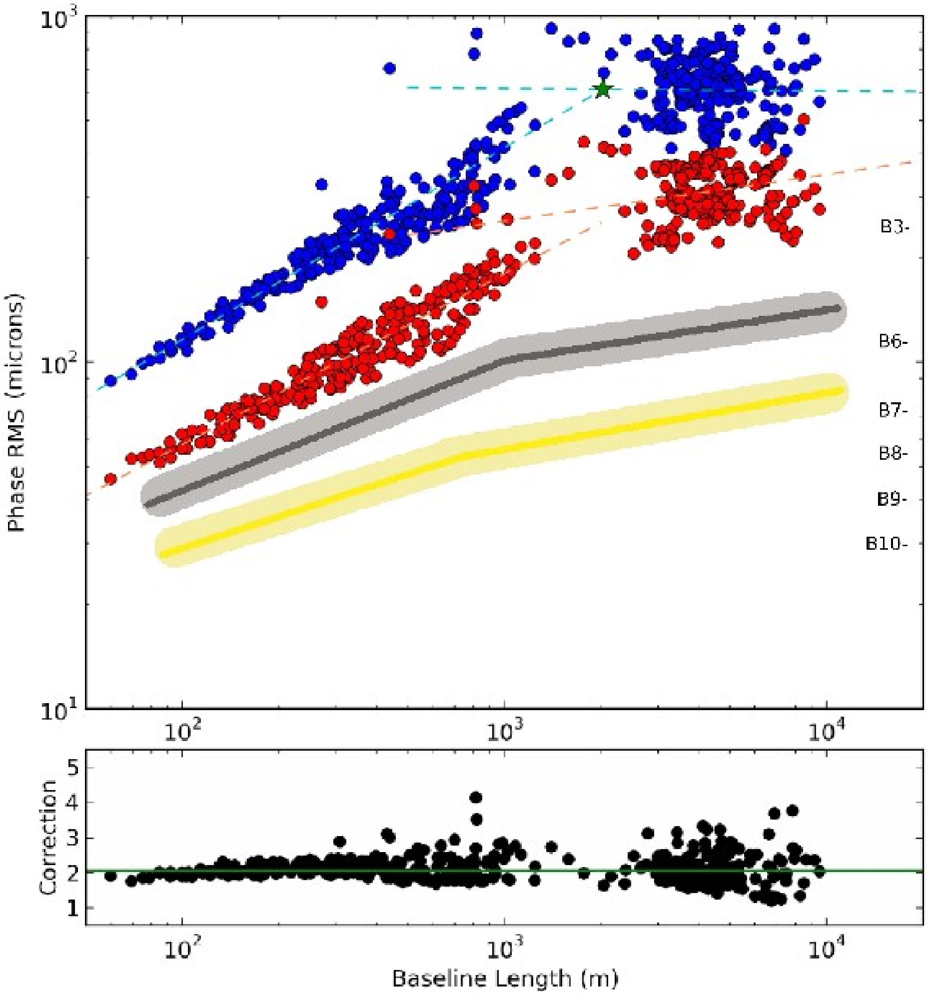
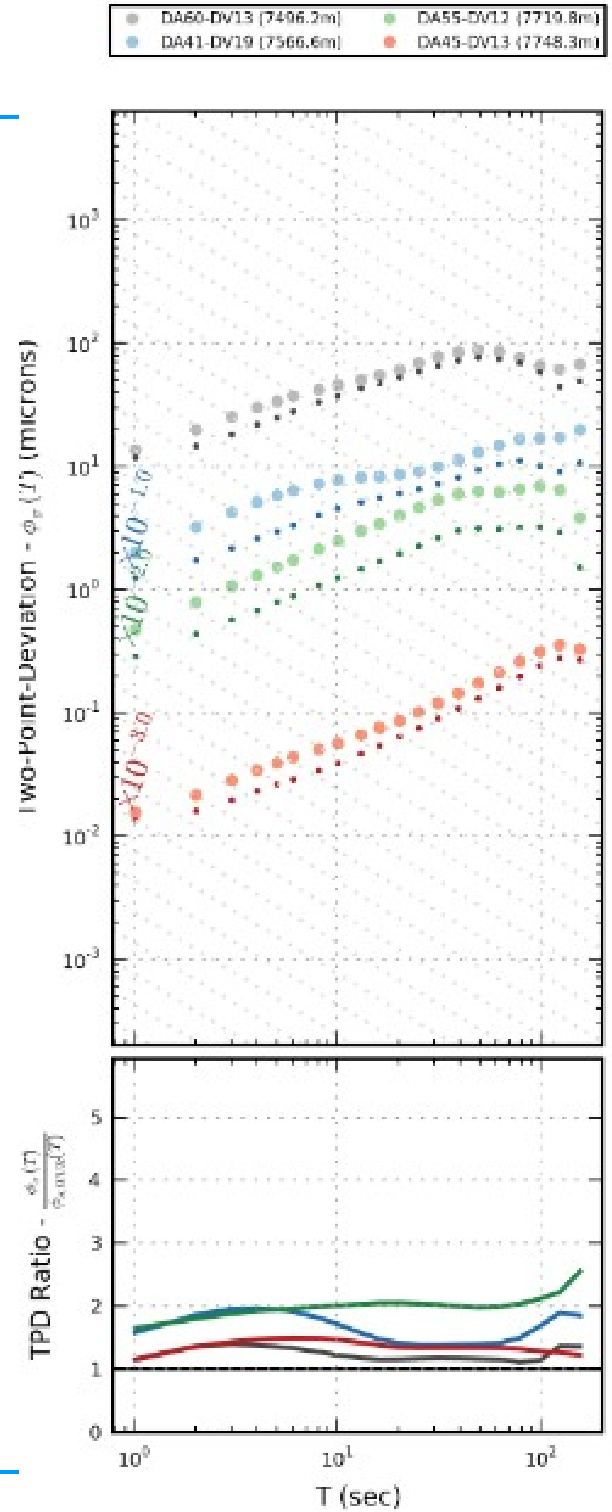
Suggested ways out – preliminary ideas

Shorter integrations + selfcal?





L.Maud, R. Tilanus, et al. - ALMA Memo 606 + A&A2017